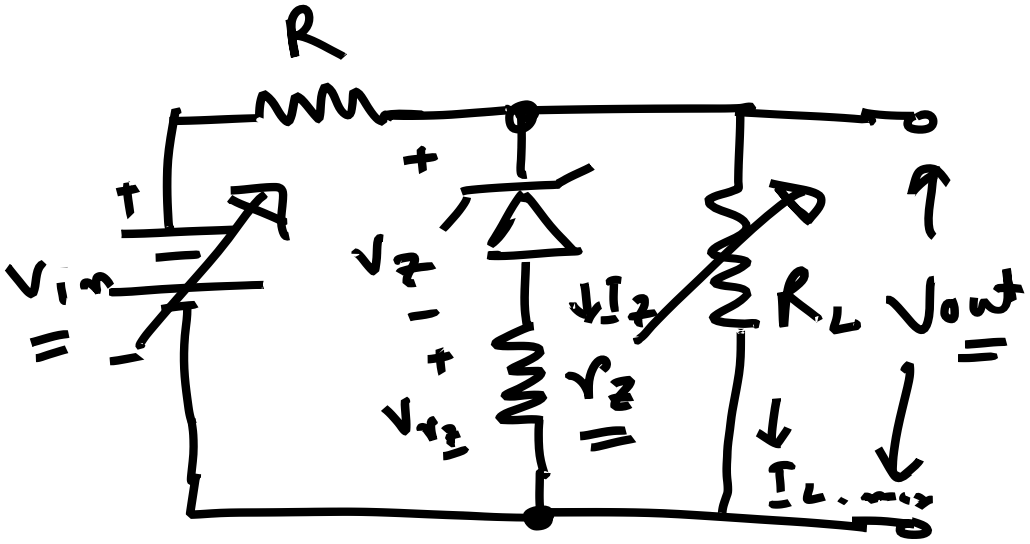
Zener diode as voltage regulator



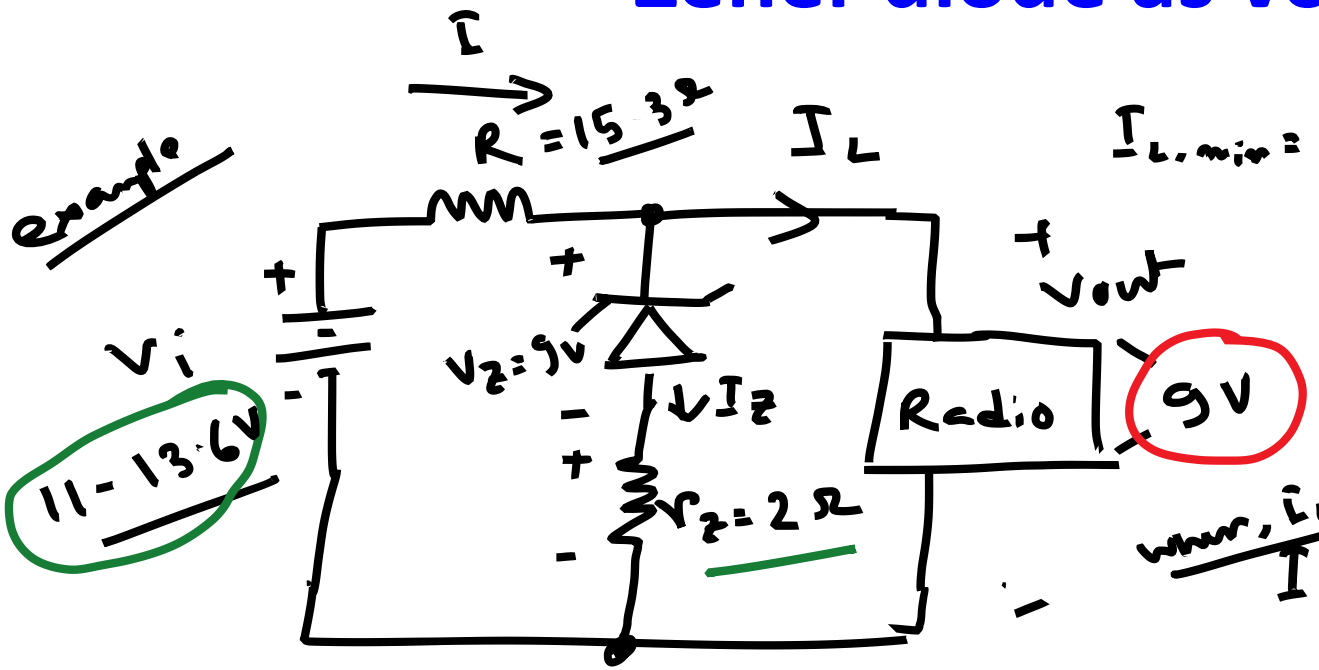
Figures of Merit

(i) Source regulation $= \dfrac{\Delta V_{out}}{\Delta V_{in}} \times 100\%$

(ii) Load regulation

$$= \frac{V_{out,\,no\,load} - V_{out,\,full\,load}}{V_{out,\,full\,load}} \times 100\%$$

Zener diode as voltage regulator



example

$I_{L,min} = 0$, $I_{L,max} = 100\,mA$

① Source regulation = $\frac{\Delta V_{out}}{\Delta V_{in}} \times 100\%$

$\Delta V_{in} = (13.6 - 11) = 2.6\,V$ ✓

when $I_L = 0$

$I = I_z = \frac{13.6 - 9}{15.3 + 2} = 0.265\,A$

$V_{out,max} = 9 + I_z R_z = 9 + 0.265 \times 2$

$V_{out,max} = 9.53\,V$

$V_{out,min}$?

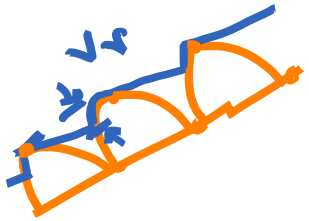
$I = \frac{11 - 9}{15.3 + 2} = 0.115\,A$

$V_{out,min} = 9 + 2 \times 0.115 = 9.23\,V$

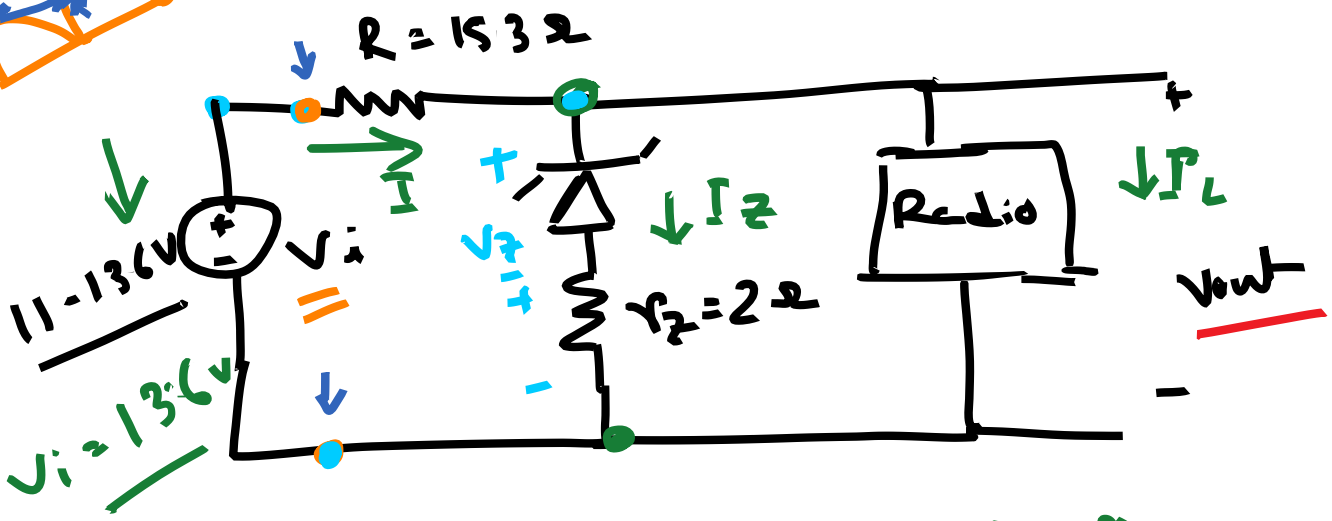
$\Delta V_{out} = (9.53 - 9.23)\,V = 0.3\,V$

Source regulation = $\frac{0.3}{2.6} \times 100\%$

$= 11.53\%$



Zener diode as voltage regulator



Load regulation

$$= \frac{V_{out,NL} - V_{out,FL}}{V_{out,FL}} \times 100\%$$

No load, $I = I_z$, $I = \frac{13.6 - 9}{15.3 + 2} = 0.265\,A$

$V_{out,NL} = 9 + 2 \times 0.265 = 9.53\,V$

$$= \frac{9.53 - 9.35}{9.35} \times 100\%$$

$\approx 1.9\%$

Full load, given, $I_{L,max} = 100\,mA = 0.1\,A$

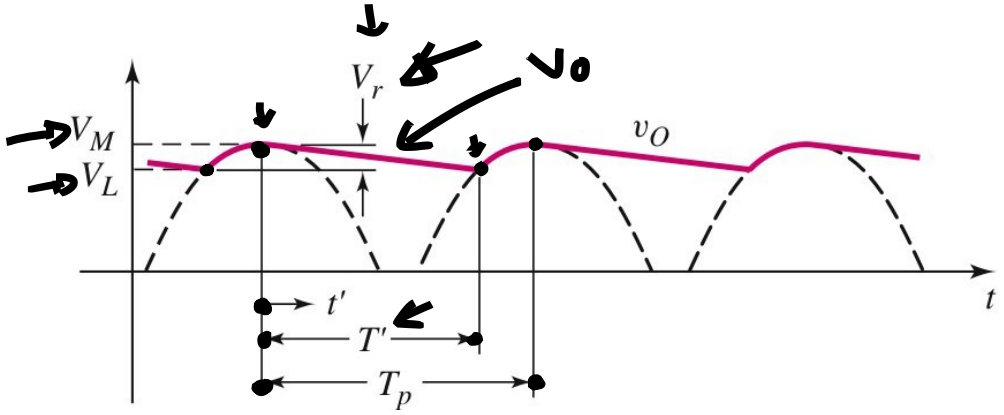
$$I_z = I - I_L = \frac{13.6 - (9 + I_z \times 2)}{15.3} - 0.1$$

$I_z = 0.176\,A$, $V_{out,FL} = 9 + 0.176 \times 2$

$= 9.35\,V$

Ripple voltage in rectified output

Ripple voltage



$$v_o(t) = V_m \exp\left(-t/\tau\right) = V_m \exp\left(-\frac{t}{RC}\right)$$

$$V_L = v_o(T') = V_m \exp\left(-\frac{T'}{RC}\right)$$

$$V_r = V_m - V_L = V_m - V_m \exp\left(-\frac{T'}{RC}\right)$$

$$V_r = V_m\left[1 - 1 + \frac{T'}{RC}\right]$$

$$\rightarrow V_r = V_m \cdot \frac{T'}{RC}$$

$RC \gg T$ $\quad$ $T' \ll RC$

T, T_p

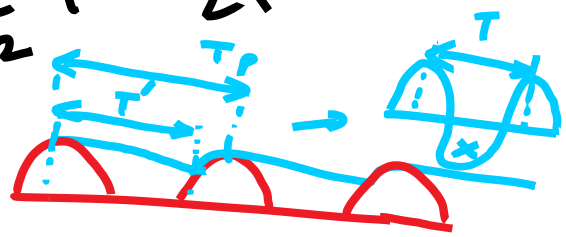
$$T_p \exp\left(-\frac{T'}{RC}\right) \simeq 1 - \frac{T'}{RC}$$

$$T' = T_p$$

$$T_p = \frac{1}{2}T = \frac{1}{2f}$$

$$f = \frac{1}{T}$$

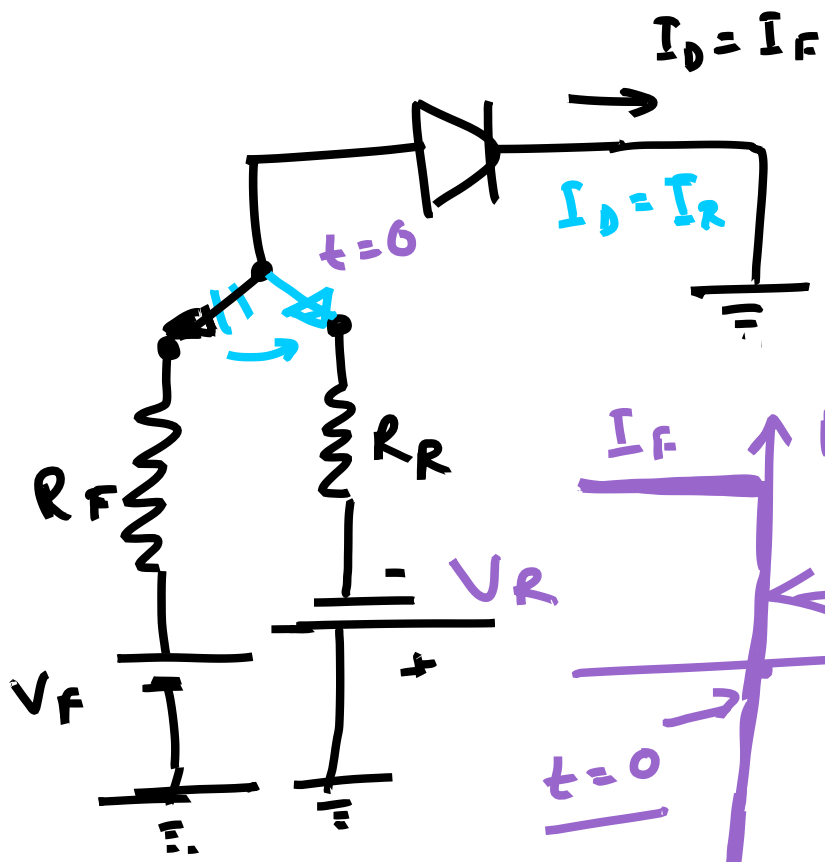
$$V_r = V_m \cdot \frac{T_p}{RC} = \frac{V_m}{2fRC}$$ ← F.W.R



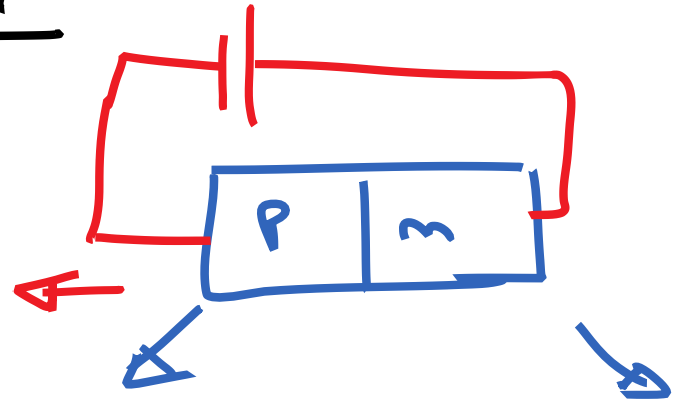
H.W.R, $T_p = T$, $V_r = \frac{V_m}{fRC}$ ← H.W.R

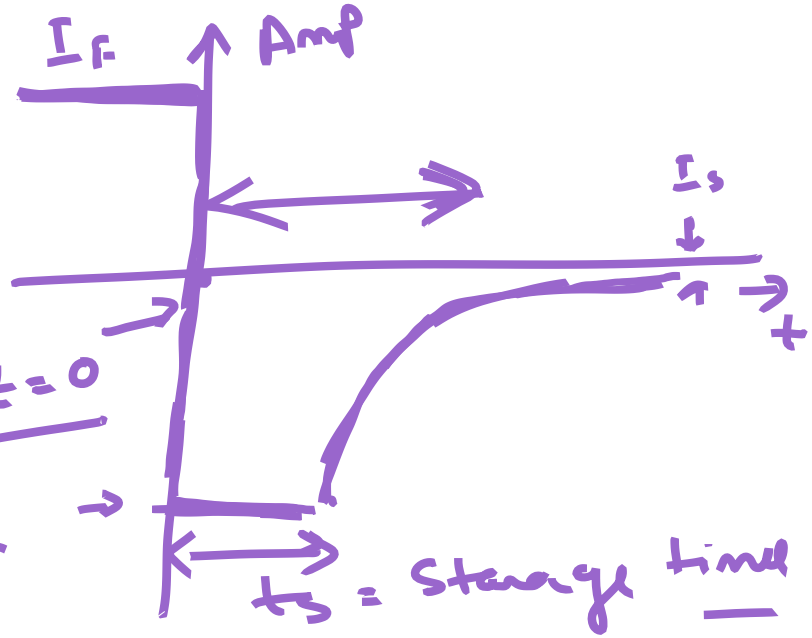
Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

pn junction diode: switching transient



$$I_F = \frac{V_F - V_\gamma}{R_F}$$





$$I_R = \frac{V_R}{R_R}$$

= a magnitude.